The Continued Development of the Third-Generation Shallow Water Wave Model "Swan"

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LONG-TERM GOALS

The long-term goal of this effort is to provide a commonly accepted third-generation wave model for shallow water to the international community of scientists and engineers for the purpose of basic research and operational wave computations (public agencies such as army, navy, harbor authorities, universities and private industry such as oil companies, engineering companies, etc.).

OBJECTIVES

The main objective is to support and assist the continued development, validation and verification of the SWAN model and its use in operational conditions. The development will be based on new scientific insights in the evolution of waves in shallow water. The verification and validation will be based on field observations and laboratory experiments supplemented with numerical experiments. Operational use will be supported with first-line assistance and diagnostics.

APPROACH

The continued development of the SWAN model is envisioned as a community effort of the wave modelers presently working in this field of technology, most of whom coordinate their efforts in an international forum called the WISE group (Waves in Shallow Environments, established in 1993 as the shallow-water follow-up of the WAM group and the HISWA group).

We provide support and assistance to these ONR-designated investigators. We assist in the installation of SWAN under conventional operating systems (also as a sub-model in larger systems of models such as atmospheric and ocean circulation models). The present extensive and detailed documentation (about 100 pages) is being supplemented with introductory documentation. Questions of users are answered and errors are located and repaired (often in response to problems encountered by the users). Updated program codes (including new cycles) are communicated to all registered users. This support is operating through electronic-mail facilities. We are collaborating with ONR-designated investigators to improve the model technology of SWAN.

This approach is essentially a continuation of the development of the SWAN model over the years 1992 - 1996 by J.A. Battjes, L.H. Holthuijsen and N. Booij and their Ph.D. students. This consists of

designing, implementing and testing a fully spectral third-generation wave model for shallow water with a fully implicit propagation scheme. Battjes supervises the scientific developments, Booij supervises the numerical developments. Holthuijsen is responsible for project management and overall supervision. In addition, IJ.G. Haagsma, A.T.M.M. Kieftenburg and E.E. Kriezi (who recently joined the SWAN team) carry out the upgrading of the computer code as regards system requirements as well as regards scientific and numerical aspects and they provide first-line support for the users.

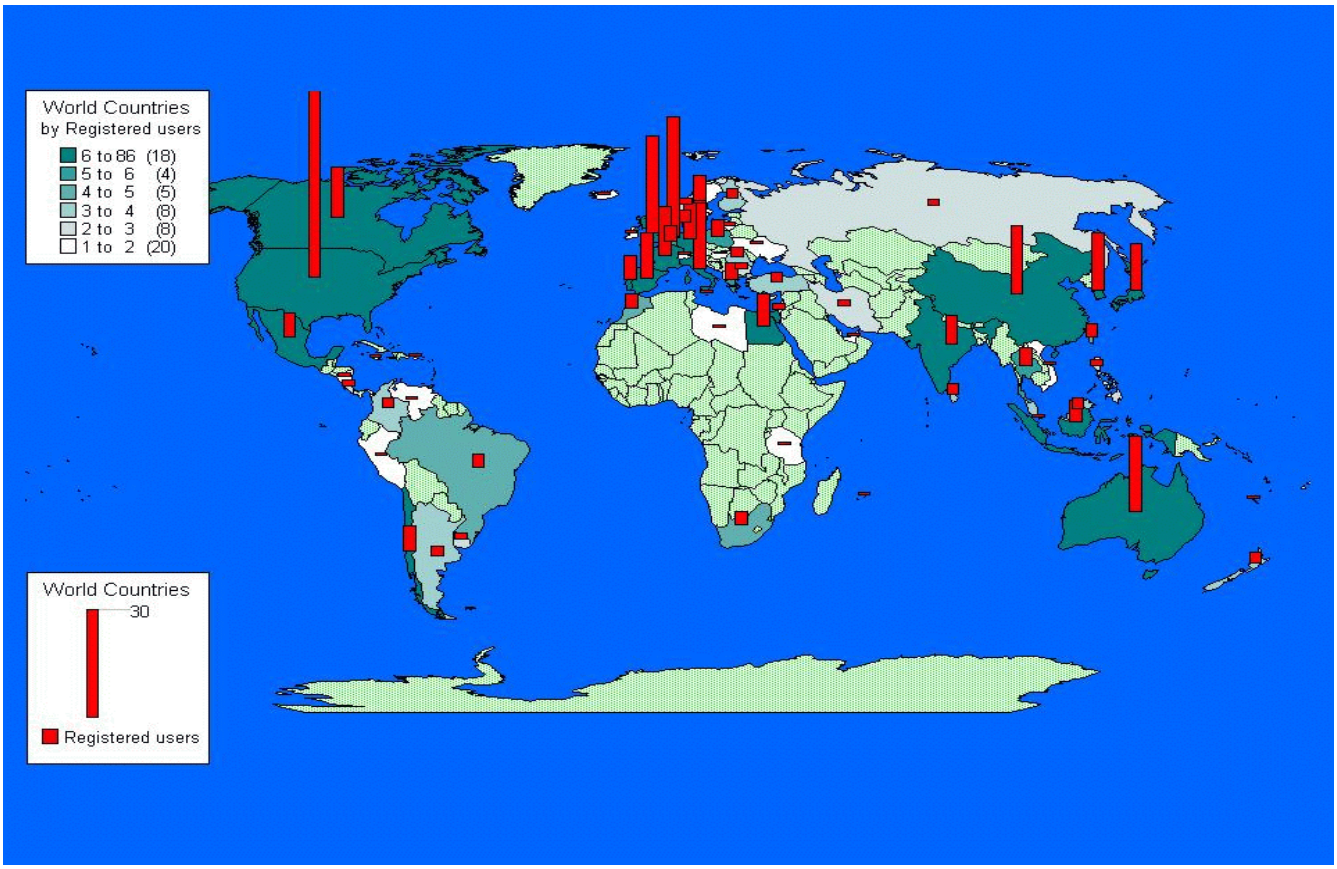

Fig.1 Distribution of SWAN users in the world.

WORK COMPLETED

A new version of SWAN, SWAN 40.11 Cycle III (to extend the present Cycle II with oceanic options) will be released in October, 2000. This version has been tested, using improved bench mark tests (see below). New features in SWAN are:

- it permits wave propagation with highly reduced diffusion (using a third-order propagation scheme for non-stationary computations and a second-order scheme for stationary computations),
- it permits wave propagation on the globe (oceans) with the basic model equation formulated and implemented in terms of longitude and latitude (optional),
- it dampens the garden sprinkler effect with a diffusion term,
- it can reflect waves against obstacles (command option)

- it allows nesting in WAVEWATCH III.

All bug-fixes for the previous release are included.

Support and assistance

a) The SWAN website is regularly updated. Coding bugs which are discovered in the authorized version of SWAN, and their fixes, are published on this site. The discussion group of SWAN on the website is slowly taking off.

b) The SWAN code (40.01, which was available from September 29th 1999 until October 2000, and previous versions) was downloaded by approximately 600 institutes from over 63 countries.

c) In the report period 176 queries of users about SWAN installation have been answered: general information (46), program bugs (44), installation (26), code (15) and usage (45).

d) The testing of the SWAN code with the Lahey Fortran 95 compiler version 5.0 (severest level) was continued.

e) One violation of the Fortran character set (\) was removed in the new SWAN code, which makes it suitable for Linux and SUN-systems as well.

f) Some of the script files for Unix provided on the homepage have been updated, and are now also suitable for Linux.

User documentation:

a) The user manual is being updated for SWAN Cycle III, as well as the short version of the manual. These manuals will be available in Word Perfect 8, Post Script and Portable Document Format.

b) The implementation manual has been updated for SWAN Cycle III. It is available in Word Perfect 8, Post Script and Portable Document Format.

c) The programming protocol has been updated, in particular to provide for coding in Fortran90.

d) Several subroutines have been adapted to the new programming protocol.

User support, diagnostics and repairs:

a) All known coding bugs of SWAN 40.01 have been published on the homepage, together with the bug fixes.

b) The updating of the system documentation (headers of the subroutines) has continued.

Improvement of model technology

a) The second-order propagation scheme (due to H. Petit of Delft Hydraulics) and the third-order propagation scheme (due to G. Stelling of Delft Hydraulics) for stationary and nonstationary cases respectively have been implemented and tested by Rogers, Kaihatu and Booij (funded under another AWPP program).

b) These higher order schemes are default in for SWAN Cycle III.

c) Spherical coordinates are optional in SWAN Cycle III.

d) A modification of the whitecapping source term has been implemented and tested in an experimental version of SWAN. It reproduces a generic laboratory experiment of M. Donelan (where wind sea in generated in the presence of swell and where all other models are expected to fail). A test with a previous version of the virtual test bed (the RWS test bed) shows that it improves the overall performance of SWAN in terms of error statistics.

e) The new release of the SWAN code contains Fortran90 features. It therefore requires a Fortran90 compiler. The full transition depends on funding outside the present project. A start is made to remove obsolescent Fortran features from SWAN.

f) Delft University assists Alkyon (funded under another AWPP program) with implementing a more accurate method to calculate quadruplets (Resio, Tracy and Webb).

RESULTS

The significance of the above completed work is that the most advanced wave model to date for coastal applications has been made available free of charge to the international community of scientists and engineers. In this fourth year approximately 600 institutes from all over the world have introduced SWAN.

As an example the results of SWAN with the modified (experimental) formulation for the whitecapping source term are illustrated here for the Indian Ocean. It concerns a situation in which a storm off Madagascar generates swell that arrives some time later at Sri Lanka. The resulting significant wave height and mean wave period as calculated with the SWAN version that will be released in October 2000 are shown in Figs. 2 and 3. The results of the experimental version are shown in Figs. 4 and 5. The effect of the modified whitecapping is obvious: the significant wave height is only moderately sensitive whereas the mean wave period is very sensitive.

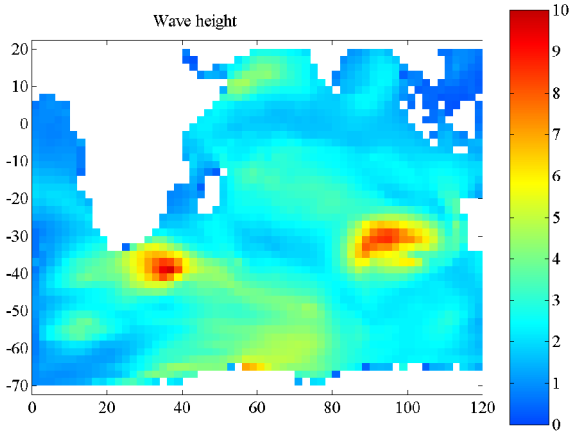

Fig.2 Significant wave height (in m), calculated with SWAN Cycle III (release Oct. 2000).

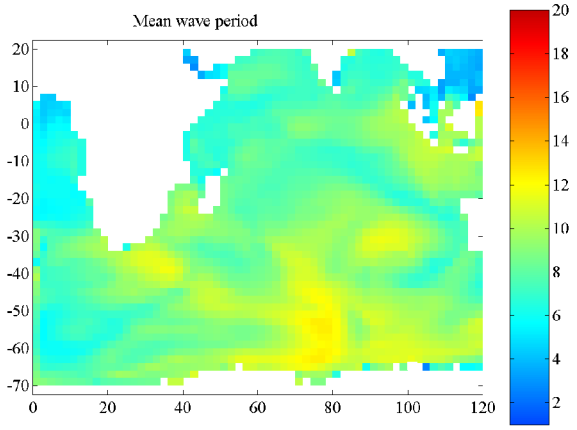

Fig.3 Mean wave period (in s), calculated with SWAN Cycle III (release Oct. 2000).

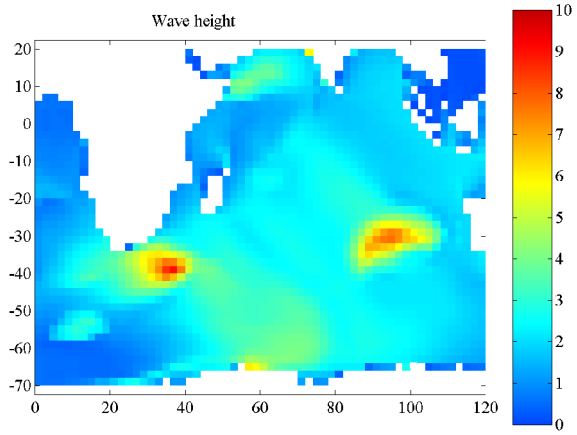

Fig.4 Significant wave height (in m), calculated with SWAN Cycle III (experimental white-capping)

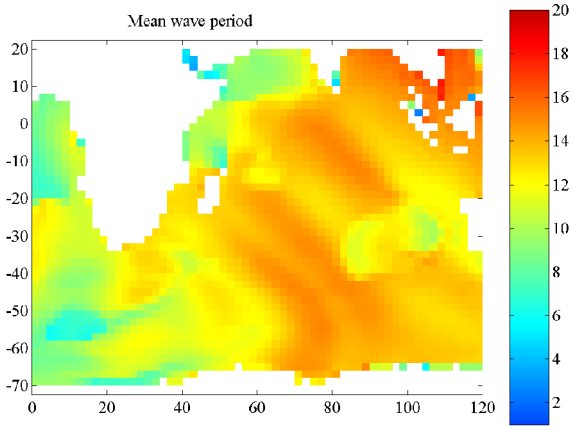

Fig.5Mean wave period (in s), calculated with SWAN Cycle III (experimental white-capping).

IMPACT/APPLICATION

SWAN provides scientists with a common platform for their research of the generation, propagation and dissipation of wind surface waves in shallow water. This community model facilitates the integration of these aspects and avoids the need to develop supplementary models in each individual research project. Moreover, with the support provided here, the results of such projects will be implemented in the fully operational SWAN model thus serving the community in general (for this purpose the SWAN model is released in the public domain). It therefore also provides a common standard for engineering applications accepted by a large number of institutions worldwide.

TRANSITIONS

The SWAN model is available free of charge to anyone (essentially in the public domain). It can be downloaded from the SWAN website. Its use is supported by the original authors under this project. SWAN is aimed at operational use by such government agencies as army and navy, national weather services and others, in the USA and abroad. Also private industry is using SWAN, mostly to determine the coastal wave climate for the purpose of design of structures and off-shore operations.

RELATED PROJECTS

Considerable efforts are being carried out by others to further develop the SWAN model. In the USA this is coordinated mostly through the AWPP program of ONR. In Europe, similar efforts (on a smaller scale) are carried out by groups of investigators funded by the EC and by national governments (notably in the Netherlands, Germany and England). The nature of these efforts is both theoretical and empirical and require extensive field work and computer experiments. The level of funding is several million US dollars per year.

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